BOSTON UNIVERSITY

GRADUATE SCHOOL

Thesis

THE TEACHING OF BIOLOGY IN THE SECONDARY SCHOOLS OF MASSACHUSETTS

By

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INDEXED OUTLINE

LIST OF TABLES

FOREWORD

Biology is perhaps the least standardized of all the natural sciences presented in the secondary schools. The vast amount of material contained in the subject together with the fact that hardly any of the material is a necessary prerequisite for the understanding of the rest has given rise to a great number of courses that are similar only in name.

During the past few years there has been an apparent change in point of view in the teaching of biology. This awakening is resulting in a transformation of the course from a monotonous study of the dead to an active, interesting view of life.

This thesis is an attempt to present the fundamental facts concerning the biology courses given in the secondary schools of Massachusetts, to bring forth the new, accepted aims and objectives of the subject and to show how the state is meeting these objectives.

H.R.K.

I. SCHOOLS IN THE STATE GIVING BIOLOGICAL COURSES

A. COURSES IN GENERAL

Biology in some form has invaded 81 per cent of the high schools of Massachusetts. Of the 252 high schools in the state 204 now give some course of a biological nature. The larger schools lead in this respect. Group I, schools of over 500 pupils, has 87 per cent of its schools giving the subject. From this the percentage ranges down to 62 for the schools of Group V, those having less than 50 pupils. Many of these smaller schools on account of limited resources feel they must cut down on their number of courses. Therefore, these schools frequently give only chemistry and physics among the natural sciences and these courses many give only on alternating years.[1]

B BIOLOGY

Courses in general biology--or at least courses so called--are given in 69 per cent of the schools of the state. Here the range of percentage from the larger to the smaller schools is somewhat different. Groups II and III, schools of from 100 to 500 pupils, predominate, each reaching 80 per cent. Group I is fourth with 64 per cent but Group V again trails with only 43 per cent. The larger schools are substituting specialized subjects for the general course. (see table II)

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[1]Data from records (1928-29 High School Reports) in department of secondary education, State House, Boston, Massachusetts.

C. PHYSIOLOGY AND HYGIENE

The second most popular of the biological sciences is physiology and hygiene. Of the 28 schools giving this course 24 are schools of over 500 pupils and 22 of the number give the course as one of two or more biological subjects. One-half of these schools--it is interesting to note--give the subject as an advanced course in one of the last two years and most of the remainder make it elementary and as preliminary to one of the other courses.

D. HYGIENE

To the list of schools giving physiology and hygiene 11 others might be added that give courses that they call just hygiene. This course like the former is chosen only by the large schools.

E. BOTANY AND ZOÖLOGY

Courses in botany, zoölogy or both are given in 15 schools of the state: 7 schools giving both botany and zoölogy and 8 giving botany only. Of these 15 schools 12 belong to group I.[2] (see table I)

F. OTHER BIOLOGICAL COURSES

Among the remaining biological subjects presented in Massachusetts schools are: civic biology, advanced biology, hygiene and nursing and agriculture. With the exception of the latter these courses are each given in only one or two of the schools of the state.

Agricultural departments are maintained in the following schools: Ashfield, Falmouth, Hadley, Hanover, Hatfield, Jamaica Plain, New Salem, Reading, Shelburne

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[2] Ibid.

Falls, Westport, West Springfield and Worcester. Orleans and Cummington also give agricultural courses. It is interesting to note that these courses are not confined to small country places.[3]

TABLE I. THE NUMBER IN EACH GROUP OF SCHOOLS IN MASSACHUSETTS GIVING EACH OF THE VARIOUS BIOLOGICAL COURSES[a]

GROUPS	I	II	III	IV	V	TOTAL
Biology	48	51	37	29	9	174
Physiology and Hygiene	24	2	2	0	0	28
Agriculture	2	4	3	3	2	14
Hygiene	11	1	0	0	0	12
Botany	7	0	0	0	1	8
Botany and Zoology	5	1	0	1	0	7
Advanced Biology	2	0	0	0	0	2
Civic Biology	1	0	0	0	0	1
Hygiene and Nursing	1	0	0	0	0	1
Horticulture	1	0	0	0	0	1
Other Biological Courses	67	34	38	32	13	204

[a]Group I over 500 pupils; Group II 201-500 pupils; Group III 101-200 pupils; Group IV 51-100 pupils; Group V under 50 pupils.

TABLE II. PERCENTAGE OF SCHOOLS IN DIFFERENT GROUPS GIVING BIOLOGY

	PER CENT IN GROUP					
	I	II	III	IV	V	TOTAL
Biology	62	80	80	64	43	69
Some Biological Course	87	85	83	71	62	81

[3]Massachusetts Educational Directory 1930

G. BIOLOGY IN GENERAL SCIENCE

The question now arises as to the biological foundation that is given previous to the presenting of the regular biology course. A general science course is given in practically every junior high school in the state and in the first year of the senior high school in those communities that do not have junior high schools. It is, therefore, most logical to look to this course to determine with what biological foundation pupils start their biology course.

Concerning this foundation G. W. Hunter says, "The junior high school movement, with the accompanying improvement in the teaching of elementary science is giving a background of science phenomena that the children of a decade ago didn't have. Health teaching and environmental science teaching have produced certain fundamental science concepts on which a course in science may be built."[4]

How much of biological content does the pupil in general science receive? Perhaps the best answer to this question would be: it depends upon the preparation and interests of the teacher. In interviewing various teachers of general science I find that anywhere from one-half to one-third of the general science course is devoted to biological material. Most of the texts include somewhere between one-fourth and one-third of this subject matter.

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[4] "New Civic Biology", G. W. Hunter, Foreword

A special study of the general science courses in the four junior high schools of one city revealed that about one-third of the course was biological. This city used the Lunt and Haley system, a system which uses a series of units, each unit containing equipment for demonstration of a particular subject in general science.[5] There are five biological units in this system:

1. Breathing and Ventilation
2. Food, diet and digestion
3. Leaves, flowers and plant study
4. Soil and seed germination
5. Yeast, mold and bacteria

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[5]Lunt and Haley General Science Units--Knot Apparatus Co., Cambridge, Mass.

II. PUPILS ENROLLED IN BIOLOGY

A. PERCENTAGE ENROLLED IN BIOLOGY

There is a very wide range in the percentage of pupils taking biology in the different schools. Taking the largest schools alone (group I) the range is from 3.1 to 34.5 per cent. The average is 14.2 per cent. This average increases as we approach the smaller schools. In group V it is 35.1 per cent. The general average for the whole state, however, 18 per cent, does not vary much from that of group I.[1]

TABLE III. PERCENTAGE OF PUPILS TAKING BIOLOGY IN EACH GROUP

	PER CENT IN GROUP					
	I	II	III	IV	V	TOTAL
Range of Percentage	3.1 to 34.5	4.0 to 37.2	6.8 to 33.5	5.6 to 47.2	18.1 to 63.6	3.1 to 63.6
Average Per Cent	14.2	15.4	17.7	24.1	35.1	18.0

B. RATIO OF BOYS AND GIRLS

Is biology a boy's or a girl's subject? The attitude in different schools varies on this point. In some schools boys are predominantly in the majority, in others girls are much the more numerous. The general

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[1] Data from Records (1928-29 High School Reports) department of secondary education, State House, Boston, Massachusetts.

averages of the largest schools in the state, however, are very close. There are 108 boys to 110 girls.[2]

In most schools where boys are in the majority in this subject, biology is required in a boys'course only or in two boys' courses and only one girls' course. The reverse is true in many cases where girls are the more numerous.

Another question that arises is the effect of a man or woman teacher in the subject. The data is hardly sufficient to warrant any general conclusions on this point. Information received from the schools in the state of over 1000 pupils revealed 10 men and 13 women as biology teachers.

A study of one school of 2000 pupils through a period of several years brought out the following facts: Previous to 1925 there had always been women teachers in biology. In the school year 1926-27, only 13 per cent of the pupils taking biology were boys. A man was added to the biology staff at that time. The percentage of boys increased during the following years. In the present year (1930-31) 40 per cent of the pupils are boys. As far as can be ascertained there were no other contributing causes to this increase.

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[2]Data from questionaire sent to high schools in the state having over 1000 pupils.

C. YEAR BIOLOGY IS GIVEN

Although you may find biology given in any year or any combination of years in different high schools, the tenth grade is by far the more popular. Seventy per cent of the schools give it in this year.[3] G. W. Hunter says, "While the place of biological science is not fixed in all parts of the country, the tendency is well marked to place it in the tenth year of the school curriculum."[4]

TABLE IV. THE GRADES IN WHICH SCHOOLS PLACE BIOLOGY

Grade	NUMBER IN GROUP I	II	III	IV	V	TOTAL
9	1	5	3	1	1	11
10	31	38	32	17	3	121
11	3	0	0	0	0	3
12	1	0	0	0	0	1
9,10	0	4	0	7	4	15
9-12	1	0	0	1	0	2
10,11	4	2	1	1	1	9
10-12	5	0	1	2	0	8
10,12	0	1	0	0	0	1
11,12	1	1	0	1	0	3

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[3]Records 1928-29 High school Reports, department of secondary education, State House, Boston, Mass.

[4]"New civic Biology" by G. W. Hunter, Foreword.

III. TIME DEVOTED TO BIOLOGY

A. PERIODS PER WEEK FOR BIOLOGY

Over 82 per cent of the courses in biology are given 5 periods per week, periods that vary in different schools from 40 to 60 minutes. Four periods per week is the next in number. The remaining schools devote 6, 7 or 10 periods weekly to the subject. (see table V)[1]

TABLE V. PERIODS PER WEEK GIVEN TO BIOLOGY

Number of Periods	NUMBER IN GROUP I	II	III	IV	V	TOTAL
4	9	8	1	1	2	21
5	38	36	34	28	7	143
6	1	2	0	1	0	4
7	0	5	0	0	0	5
10	0	0	1	0	0	1

B. LABORATORY PERIODS PER WEEK

The standard amount of time given to laboratory work is 2 forty-five minute periods each week. Over 90 per cent of the schools of over 1000 pupils give this amount of time. Some, but very few, give no laboratory work at all. These give demonstrations before the pupils once or twice a week. One school had 3 periods per week for laboratory work.[2]

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[1]Data from records (1928-29 High School Reports) department of secondary education, State House, Boston, Mass.

[2]Data from questionaire sent to high schools in state having over 1000 pupils.

C. FIELD WORK

Practically none of these large schools have any field work in biology. Lack of opportunity is the chief cause of this. Very few of the city schools, if any, would be near enough to woods, fields or other places for observing plant and animal life to go out during a laboratory period and get back for other classes. Some of the schools that were within reach of the Blue Hills or Arnold Arboretum had made a few trips to these places after school hours. The answer, to the question, "How much time do you give to field work?" was, in 75 per cent of the cases, "None".

IV. BIOLOGICAL LABORATORY EQUIPMENT IN SECONDARY SCHOOLS

A. AMOUNT OF LABORATORY EQUIPMENT

The amount of biological laboratory equipment in the various high schools varies to a marked degree. Some schools have almost nothing or perhaps a couple of hand lenses. Others have disecting desks, microscopes and specimens of animals and plants. A few, besides these things, have an aquarium, a vivarium, and a "hot house" for the raising of plants.

As a whole, however, the biological laboratories were more poorly equipped than those used for chemistry and physics. The general opinion seemed to be that you could get along with much less in biology.

Examination of some of the biological laboratories in the larger schools shows the following to be typical of the group.

(For the plan of the laboratory see diagram on page 13)

EQUIPMENT

General.

One compound microscope
Set of slides and mounting material
Several simple microscopes
Biological chart
Human skeleton
Specimens (dried) of animal types
Preserved specimens of mammalian--heart, lungs, kidneys, brain
Preservatives--Formaldehyde and denatured alcohol
Other chemicals--starch, iodine, nitric acid, lime water, zinc, hydrochloric acid, sodium carbonate
Live fish, frogs and aquatic plants in aquarium

Individual

- Forceps
- Scissors
- Scalpel
- Teasing needle
- Dissecting pans
- Earth receptacles for individual planting

This might be compared with a list suggested by Twiss:[1]

Individual Equipment

- Hand or pocket lens
- Scalpel, forceps, 2 dissecting needles
- A few high-powered lenses
- For zoölogy add bone forceps and cartilage-knives

Dissecting microscopes

Compound microscopes--at least one--ideal for each pupil to have one.

Cameras

Slide mounting material

Homes for living plants and animals
Aquarium and Vivarium

General Apparatus

- Dissecting pans
- Specimen jars
- Test tubes
- Medicine droppers
- Rubber tubing
- Chemicals
- Bones, heart, lungs, kidneys etc. in formalin

Wall Charts

Models

Animal Preparations

Human skeleton

Microscopic and lantern slides

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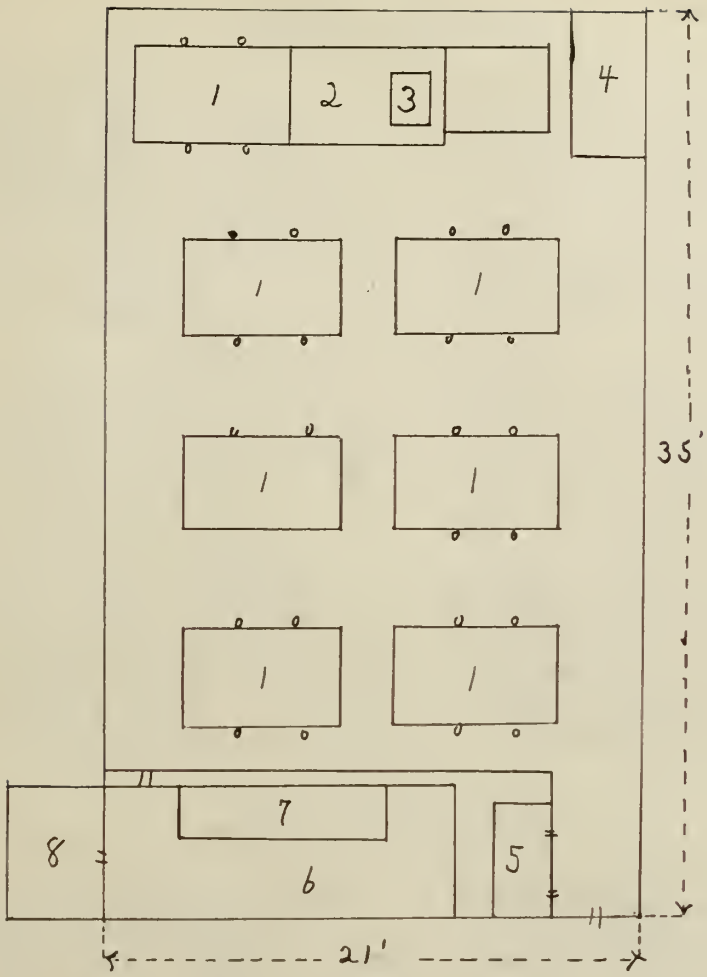
[1]Twiss, George R. "Principles of Science Teaching" Chapter XIII.



FLOOR PLAN OF TYPICAL BIOLOGICAL LABORATORY

1. Pupils' laboratory tables
2. Demonstration table
3. Sink
4. Aquarium
5. Specimen Cabinet
6. Supply room
7. Instrument cabinet
8. Plant chamber

The Bureau of Education, Department of the Interior, Suggests the following list of apparatus for a biological laboratory:[2]

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[2]Bulletin, 1927, No. 22 "Laboratory Layouts for High School Sciences"

GENERAL APPARATUS

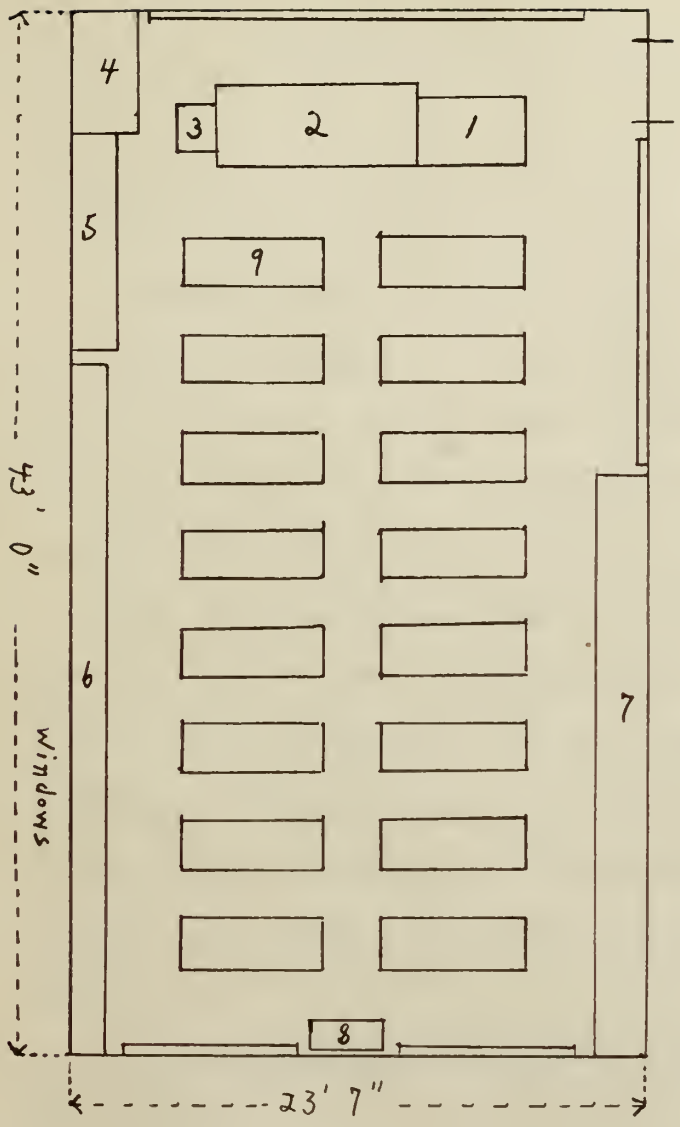
2 aquariums, 3 gal.
2 bell jars, 1 gal.
2 bell jars, 3 gal.
2 bladders (osmosis)
4 bottles, wide mouth
1 pr. bone forceps
2 trip scales
2 iron wts. 10 g. to 500 g.
2 corks, asstd. 0-11
2 cork borers, set of 6
2 corros. sublim. tabl.
6 flasks, 500 cc.
100 flower pots
6 funnels, 75 mm.
2 funnels, 6 inches
9 lbs. glass tubing 5-13mm. asst'd.
2 grad. cylin. 250 cc.
2 insect nets
200 insect pins, No. 0
200 insect pins, No. 3
2 insect spreading boards
8 litmus paper, blue
8 litmus paper, red
24 medicine droppers
40 petri dishes, 50 mm.
24 rubber stoppers, 1 hole
24 rubber stoppers, 2 hole
36 ft. rubber tubing 3/16"
36 ft. rubber tubing 1/4 "
3 sq. ft. rubber dam.
144 test tubes, 4 by 1/2, per 12
144 test tubes, 6 by 3/4.
24 test tube brushes
12 test tube racks
6 therm. 110° C. and 220° F.
6 Tripods, 6 inches
2 vasculum, collecting case
1 water bath, copper, constant water level, 6 inches.

MODELS AND CHARTS

1 model, each, human skull and brain; human ear; human torso
1 set physiology, anatomy and hygiene charts
1 set botay charts
1 set natural history and mineralogy charts
1 set life histories of insects, squash bug, cotton boll weevil, apple borer, cucumber codling moth, peach borer, lady bug, honey bee, silk worm

INDIVIDUAL APPARATUS

12 batter jars, 5x7"
48 bottles, 3 oz.
24 bottles, cyanide
48 breakers, 250 cc.
24 dishes, crystalliz.
24 dishes, evaporat.
24 dissecting sets
24 dissecting pans
24 pkg. filter paper
24 flasks, 250 cc.
24 glass plates, 4 x 4
24 microscopes, dissecting
24 pinchcocks
24 pneumatic troughs
24 ring stands, 3 ring
24 rubber stoppers, 2 hole, #3
24 rubber stoppers, 2 hole, #8
24 test tubes, hard, 6x3/4.
48 thistle tubes
96 watch glasses, 3 inches
24 wire gauze squares, 5 inches
12 Bunsen burners
36 ft. rubber tubing, 1/4 inch



1. Teachers' Desk
2. Demon. Desk
3. Sink
4. Aquarium
5. Germinating Bed
6. Wall shelf
7. Cases
8. Lantern
9. Pupils' Desks

Scale--1 inch--8 feet

Biology Laboratory and Recitation Room

for 32 Pupils-Area 1013¼ Sq. ft.

Tables for two pupils 24" x 72". All pupils face front of room and have light from left side.

Plan by C. D. Kingsley--May 1924

V. TEXTBOOKS USED IN THE STATE

A. Names and Distribution of the Major Texts Used.

The textbook used in a subject is, as a rule, a very good barometer of the contents of that course. A study of five or six of these indicators will give us a very good idea of what biological material is being presented in the schools of this state.

Of schools having over 200 pupils at least 75 per cent use one or two of five textbooks and the users of two of this five would include over 50 per cent of these schools. Although data obtained concerning the other schools are less complete the indications from reports received are that the same ratio holds true throughout the state.

The following are the 5 biology texts used most extensively:

"Biology for Beginners" by Truman J. Moon
"New Biology" by Smallwood-Reveley and Bailey
"Biology and Human Welfare" by Peabody and Hunt
"New Essentials of Biology" by George W. Hunter
"New Civic Biology" by George W. Hunter

It is interesting to note that some of the schools use two of these texts and follow neither one very closely. See table VI for more complete data.

TABLE VI. USE OF CHIEF TEXTS IN SCHOOLS OF OVER 200 PUPILS

Texts (Authors)	Number using this text			Percentage of schools in which the text is used
	Only	With another	Other[a] course	
Moon	24	18	5	42%
Smallwood R-B	14	7	2	21%
Peabody-Hunt	6	8	1	14%
Hunter (Civic)	4	6	1	10%
Hunter (Essentials)	5	3	0	8%
Linville	2	2	3	4%

[a]Those using text in some course other than one called Biology.

B. Content of Texts

The six most used textbooks in the state might well be divided into two classes. First, there are those that have well defined sections in botany, zoölogy and human biology. That is, books that devote one section to plant life, another to animal life and a third to the human phases of biology. In the other class are those that include two or all of these phases of biology in one chapter. They might, for example, be discussing respiration but not respiration for the insect alone. Breathing would be discussed in the animal, in the plant and in human beings. In discussing the content of these texts each of these classes will be treated separately.

1. TEXTS WITH SEPARATE SECTIONS

Each of the books in the first class give a certain amount of preliminary material that might be called introductory or general biology. The number of pages devoted to this varies from 6 to 48, the average being 30 pages.

a. GENERAL BIOLOGY

The material contained in the first chapters of "Biology for Beginners" by Moon is typical of this general biology. The following is a brief outline of this material:

I. Introduction
   1. Definition of biology
   2. Reasons for study of biology
   3. Organic and inorganic things
   4. Familiar biology

II. The likeness of all living things
   (Processes common to all organic things, e.g. Nutrition, respiration-------)

III. Elements, the alphabet of living things
   1. Oxygen and oxidation
   2. Occurrence, Properties and use of common elements.

IV. Compounds, biology's building materials
   1. Water, Carbon dioxide,-------
   2. Method of testing

V. Protoplasm, the "bios" of biology
   1. Protoplasm--its composition and properties
   2. Cells, tissues, organs, systems
   3. Adaptation

In brief this general biology contains a definition and reasons for study of biology, the unit structures of a living organism and perhaps a concrete example of biology.

"New Biology" by Smallwood-Reveley and Bailey presents an interesting feature in its chapter on general

biology. It takes up the life of an apple tree, bringing in all the possible phases of biology--even the insects which feed on it. This will be discussed in more detail further on under methods.

b. BOTANY

The number of pages devoted to botany by those texts ranges from 72 to 166, the average being 124 pages. The study of plant life comprises an average of 23 per cent of each book. This does not include botanical material in sections of a strict economic nature. This material will be considered separately.

There is no uniformity in the texts as to when in the year botany should be studied. Two of the four texts under consideration here put it first, that is, right after the chapters on general biology. The other two put it after the study of zoölogy. One of the authors, however, suggests in the foreword that the teacher take up the different phases as convenient without regard to the order of the text.

The following is an outline typical of these sections dealing with plant life:

I. Seeds and Germination

1. Parts and functions of a typical seed--the bean
2. Conditions necessary for germination of the seed
3. Stages in germination

II. The Root, the Plant's absorbing organ

1. Structure of roots
2. Functions of roots
3. Adaptations of different kinds of roots
4. Osmosis

III. Stems, the plant's transportation system

1. Structure and functions of the stem
2. Forms of stems
3. Buds
4. Grafting

IV. Leaves, the plant's work-shop

1. Structure and functions of leaves
2. Photosynthesis, digestion, respiration
3. Modified forms of leaves
4. Adaptation of leaves

V. Flowers and their work

1. Structure and functions of flowers
2. Adaptations for pollination

VI. Fruits and their uses

1. What a fruit is
2. Types and functions of fruits

VII. Spore bearing plants

1. Algae--harmful and beneficial
2. Fungi--plants that lack chlorophyll

VIII. Microscopic plants

1. Useful and harmful forms
2. Their control

As seen by the outline above the major part of the botany section is devoted to the structure, functions and adaptations of different parts and stages of seed plants. Most of the books include a chapter or two of the fungi, the algae and microscopic plants in general.

Linville in his "Biology of Man and Other Organisms" has added two interesting chapters, one on "Mosses and Ferns" and another on "The Farm, a Comprehensive Biological Unit." The latter chapter sums up and makes practical much of the preceding material.

The subject of forests and their conservation is taken up by some texts along with this botanical material. Others, however, reserve this for a separate section on economic biology. Moon, in his book, uses the latter method.

C.
ZOÖLOGY

Zoölogy surpasses botany in the amount of consideration received by the authors of these texts. The average number of pages given to zoölogy is 167 compared with the 124 pages given to botany. Only one author, (Hunter) fails to give more space to the animal phases of the subject.

The general tendency is to devote a larger part of the zoölogical work to the invertebrates. There is an average number of 78 pages of vertebrate zoölogy and 86 pages of invertebrate material. The text by Smallwood-Reveley and Bailey is the only one to give predominance to the higher animals although Moon's book approaches this goal.

The task of making an outline which would typify the zoölogical material presented in the texts is a little more difficult. There is little uniformity in the invertebrate material presented. The chapters on vertebrate zoölogy, however, are quite uniform. The subjects as outlined by Linville are as typical as any and perhaps a little more complete. After these subjects are presented variations in the other texts will be noted.

Linvilles' list of subjects in Zoölogy:

1. The slipper animalcule and its near kin
2. Sponges

3. Jellyfish and coral polyps
4. Starfishes and sea urchins
5. The earthworm and its kindred
6. Insects and their near relatives
7. Mussels and their near kin
8. The fishes
9. Frogs, toads and salamanders
10. Snakes and other reptiles
11. Birds
12. Mammals

It will be seen that this list covers the animal kingdom very completely and the order followed is that of the regular classification. It might also be noted that Linville gives much more space to the invertebrates.

The other texts are very similar in content in regard to the vertebrates but less complete on the invertebrates. One subject, however, that they all include is a study of insects. Smallwood-Reveley and Bailey make this study three-fifths of all the work on the invertebrates.

The study of protozoa, worms, crustaceans and sometimes molluscs are given some consideration. The groups that are seldom touched upon are the sponges, jellyfish and echinoderms.

Most of the texts still adhere to quite a little morphological material. There is a tendency, however, in most of the books to give a little more emphasis to function, adaptation and economic importance of animals.

d. HUMAN BIOLOGY

Human biology is now included in any up-to-date biology text. This section will deal with not only human physiology and anatomy but personal hygiene, sanitation, food and drugs.

Human biology claims an average of 139 pages in the texts of this class. The range here is more uniform. The smallest number of pages devoted to the subject is 116, the highest is 181 pages.

The following outline contains the subjects on human biology common to most of the texts:

I. Resemblances between man and other animals

1. Man as a mammal
2. Primitive man

II. Digestion and absorption

1. Digestive organs
2. Digestive changes
3. Absorption and assimilation

III. Foods, stimulants and narcotics

1. Food values
2. Balanced ration
3. Drugs and the human body

IV. The blood and its circulation

1. Function
2. Composition of blood
3. Structure of the system

V. Respiration

1. Comparison with lower animals
2. Structure of system
3. Changes in air and blood
4. Ventilation

VI. The nervous system and organs of sense

1. Structure with localization of function
2. Touch, taste, smell, hearing, sight
3. Care of the eyes

VII. Excretion

1. Source of waste
2. Organs of excretion

VIII. Good Health and how to keep it

1. Sanitation
2. Health and disease

Almost without exception each author starts his section on human biology with a chapter on man and the lower animals. He then takes up the chief systems of the body bringing in a chapter on food and drugs in connection with nutrition. The last chapter or two are devoted to health and sanitation.

e. ECONOMIC BIOLOGY

To give the amount of economic biology in these texts with any degree of accuracy would perhaps be impossible since more or less of this phase of biology is interwoven with the botany, zoölogy and the human biology. The following data, therefore, will include only that material that is definitely in a separate section on economic biology.

Only three of the four texts in this class have sections on the economic phase. The average space given to the subject by these three texts is 57 pages.

The section of Moon's book on the subject is typical of this material. The following is a brief outline of this section.

I. Economic biology of plants

1. General uses
2. Harmful forms--plant uses in detail

II. Economic biology of invertebrates

1. General uses of animals
2. Harmful insects and their treatment

III. Economic biology of vertebrates

1. Fish, amphibia, reptiles, birds
2. Mammals

IV. Biology and agriculture

1. Soil formation
2. Plant breathing and protection
3. Animal husbandry

V. Economic importance of forests

1. Value of forests
2. Enemies of forests
3. Protection

The outline above covers practically anything that is found in these texts on economic biology. Most of the books are somewhat less complete on the subject.

TABLE VII. CONTENT[a] OF TEXTS IN CLASS 1[b]

Texts (Authors)	General Biology		Botany		Zoology Invert.		Zoology Vert.		Human Biology		Economic Biology	
	P.[c]	Ch.	P.	Ch.	P.	ch.	P.	Ch	P.	Ch.	P.	Ch.
Moon	41	6	115	12	88	8	87	8	120	11	62	5
Smallwood R-B	48	5	166	9	89	5	117	5	181	10	68	3
Hunter	22	3	143	10	89	7	50	1	116	8	0	0
(Essen.)			72	7								
Linville	6	1			75	7	57	5	139	10	45	3

[a] Content only that would come under these table headings.

[b] Texts that have special section on each of the phases of biology as indicated in headings of table above.

[c] P.--number of pages; Ch.--number of chapters.

2. TEXTS UNITING SECTIONS OF BIOLOGY

There is a modern tendency in the field of biology to ignore any lines, real or imaginary, that may exist between botany, zoölogy and human biology. In this plan all phases of biology are brought together in one section. Respiration is discussed in plants, in animals, in human beings. A problem is given and taken up thoroughly. Since almost any real problem will involve more than one phase of biology all phases must be given in one chapter. As this, perhaps, is more a question of method and presentation this modern tendency will be discussed more in detail further on under that heading.

"Biology and Human Welfare" by Peabody and Hunt and "New Civic Biology" by Hunter come nearer to meetin this modern trend than any of the texts used commonly in the high schools of the state. The following are some of the subjects discussed in one or the other of these books illustrating this type of material:

Living things and the environment
How living things are able to work
How living organisms are constructed
How foods are prepared for distribution and use in living things
Man's control of his environment
The relations of animals to disease
The relations of plants and animals
How living organisms breathe
Responses in plants and animals
How certain living things carry on reproduction

3. HEREDITY AND EVOLUTION

The subjects of development of man, heredity and evolution are treated rather sparingly in most of the texts. The books of Moon and Linville are the only ones that treat all these subjects with any degree of completeness.

Moon has a chapter on the development of man in which he gives the relation of man to other animals and the chief evidences of evolution. He has another chapter called the "Methods of Evolution" in which he discusses evolution from the historical standpoint emphasizing Lamarck and Darwin. In a portion of a third chapter he devotes about 3 pages to Mendelian inheritance.

The material in the other texts on the subject is meager. Hunter in his civic biology book gives a chapter on breeding and one on improvement of the human race. Smallwood-Reveley and Bailey and Hunter in his "New Essentials of Biology" each give a chapter on man as a mammal. The Peabody and Hunt book does not touch the subject in any way.

4. HISTORICAL BIOLOGY

Another of the topics not always treated very thoroughly is that of historical biology or the lives and achievements of great men in the biological field. Three of the books each give a short chapter on these biographies. The men most commonly treated are Pasteur, Burbank, Huxley and Darwin. One book treats Mendel at some length.

The most complete of these texts in the field of historical biology is that of Peabody and Hunt. This book, however, does not devote a special chapter to the subject. The material is distributed through the book.

5. PICTURES AND DIAGRAMS

All of the major texts of the state are very well illustrated. In the six texts presented there is an average of 310 diagrams and illustrations.

An examination of one text having over 400 diagrams and illustrations showed 169 pictures of plants and animals, 124 of parts of plants and animals, 84 diagrams illustrating, for example, the structure of the eye, 14 portraits of biologists and 30 miscellaneous pictures most of which were scenes.

6. UNIFORMITY OF TEXTS

The question is asked, "Is there any uniformity in these texts?" Upon a superficial examination the answer might be, no. After a more careful study, however, it will be seen that in regard to content there is much similarity in these books. Of course, each author emphasizes a particular phase of the subject more than another, but in regard to the essentials of botany, zoölogy and human biology there is a sameness. Where the greatest difference lies in biology texts is in the manner or method or presentation of material.

B. PRESENTATION OF MATERIAL

Is biology a unit science or is it a mere combination of botany, zoölogy and hygiene? Around the author's attitude to these questions hangs the whole question as to the presentation of the material in his text. Most of the authors agree that biology is a unit science but few seem willing to accept it to the extent that they disregard wholly the lines between its different parts.

In discussing presentation of material in the texts the same division of texts might be made as that made under the study of content, namely, those books giving separate sections on botany, zoölogy and human biology and those combining these features in one section. Each of these divisions represents a method of presentation.

Authors of texts in the first division in their treatment of the subject present a specimen typical of a group. They give facts conceiving structure and adaptation of parts and as a whole confine the study to this animal or plant. They are presenting either plants or animals, not both. They do, however, break down the traditional lines between the different parts of biology sufficiently to present in the same chapter the relation of the plant or animal to human welfare.

Strange to say, the best example of the problem method of presenting biology or the method that combines all phases of biology in one chapter is found in a book that treats each of these subjects in a separate section. I am referring to the first chapter in "New Biology" by Smallwood-Reveley And Bailey, "The Life of an Apple Tree." An outline of this problem will probably be most effective in illustrating the method of presentation.

The Life of an Apple Tree

1. The sprouting seed of the apple
2. The plant and its newly developed roots
3. The leaf and its enemies

a. The leaf as a factory
b. Life of gall fly--one of the insect enemies of the leaf

4. The stem and the borer
   a. Functions of stem or trunk of apple tree
   b. Its enemy, the borer
5. The root and the grub
   a. The roots and the soil
   b. The insect enemies of the root
6. The blossom and the bee
   a. The blossom as the first step to produce fruits
   b. Major parts of the blossom
   c. The part bees play in pollination
7. The fruit and the life cycle
   a. Flower develops into fruit containing seeds
   b. Fruit attracts animals which distribute seeds for another cycle
8. The life history of the codling moth--an enemy of the apple
9. The carbon cycle as illustrated by the decaying apple tree
10. Man's work in improving the apple tree
    a. Budding and Grafting
    b. Cross pollination
11. Control of the enemies of the apple tree

Here in the problem of the life of an apple tree the various botanical phases were included with the study of the seed, roots, stem, blossoms and fruit. The zoölogical phases were included in the study of the insect enemies of the tree. The relation of the problem to human welfare was considered. The carbon cycle was also illustrated by the problem. This is a method of teaching science called by Dr. Newell[1] the "correlation topic method."

Some authors use a different method in presenting biology as a unit subject. Instead of taking a problem as illustrated above, they take a system or life process

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[1] Dr. Lyman C. Newell, Professor of Chemistry and instructor in teaching of high school science, Boston University.

and carry the discussion through the different animals and plants, finally showing the relationship of the particular system to that in the human body. The following chapters from one text illustrate this method: "How living organisms breathe," "How certain things carry on reproduction."[2]

D. OUTLINE OF A TYPICAL COURSE IN BIOLOGY

By way of summing up the material contained in the biology textbooks used in the state I have prepared the outline below of a typical one-year course in biology. This outline is based on these texts.

This outline adheres more closely to the texts having separate botany, zoölogy and human biology sections since these books are by far in the majority.

Outline of A Typical One-Year Course in Biology

1st week I. Introductory Biology

A. A project example--life of an apple tree
B. Likeness and Composition of living things
C. Important life processes

3rd week II. Animal Biology

A. The grasshopper and his relatives
B. Life and Control of destructive insects
C. The crayfish and his relatives
D. The earthworm and his relatives
E. The simplest of animals--Protozoa

11th week F. Fishes
G. Frogs
H. Reptiles

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[2]"Biology and Human Welfare" by Peabody and Hunt--Chapters 12 and 13.

I. Birds
J. Mammals

19th week III. Evolution and Development of Man

21st week IV. Human Biology

A. Digestion and Foods
B. Respiration--Ventilation
C. Circulation and assimilation
D. Nervous System and Sense Organs
E. Excretion
F. Bacteria and Disease

29th week V. Plant Biology

A. Seeds and germination
B. Roots--absorption and osmosis
C. Stems--forms, function, structure
D. Leaves--functions--structure
E. Flowers and Fruit--pollination
F. Spore-bearing plants

VI. STANDARD BIOLOGY TESTS USED

A. BIOLOGY TESTS

The objective type of examination which seems to be replacing the subjective varieties in most subjects has invaded the field of biology. The chief reasons offered by most teachers on why they use this type of test is that you can cover more ground in these tests and that they are easier to correct. Another argument sometimes given-- and perhaps the strongest one-- is that the marks given on these tests are much more accurate. They do not vary with the mood of the instructor.

There are two of these standard tests in common use in this state, the "Blaisdell Instructional Tests in Biology", a series of 25 tests and the "Rush-Cossmann Biology Test"[1], a final examination. These tests though constructed from different sources and serving somewhat different purposes are very similar in the style of the questions given.

B. THE BLAISDELL TESTS

The group of "Blaisdell Instructional Tests" is as the name implies a group of tests designed for instructional purposes, to let teacher and pupil know the progress made on any unit of work. There are 25 of these units covering the various phases of biology.

The material in these tests was selected to conform with outlines of biology courses in various cities and

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[1]Published by World Book Company, Yonkers-on Hudson, New York

states and with the most widely known textbooks in the subject.[2] The list of subjects, therefore, looks a great deal like the table of contents of a standard biology text.

The 25 tests are distributed as follows:

1 test on introductory material
7 tests on animal biology, including
  3 tests on invertebrates (insects, crustaceans and protozoa)
  3 tests on five classes of vertebrates
  1 summary test on animal biology
8 tests on human biology, including
  5 tests on food and the systems of the body
  2 tests on bacteria, sanitation and health
  1 summary test on human biology
8 tests on plant biology, including
  4 tests on seeds, roots and other parts of plants
  3 tests on algae, non-flowering plants and forests
  1 summary test on plant biology
1 concluding test on plant biology, including heredity and evolution

The Blaisdell tests use several types of objective questions. Among the most common are the following:

1. Completion of sentence having one word missing.

   Example: Food is oxidized in a cell to produce heat and _____. ( )

2. The choosing of 1 correct answer out of 4 given.

   Example: The study of insects is termed--
   1 Entomology 2. ecology 3. agriculture
   4. zoology---- ( ).

3. The labeling of a diagram by connecting up a given list of names with numbers given to the parts of the diagram.

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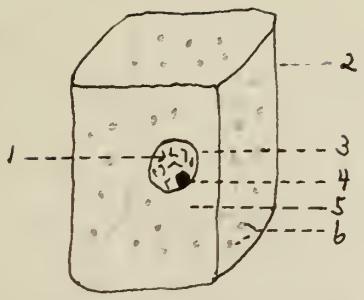
[2]"Blaisdell Instructional Tests" in Biology Foreword to teacher.

Example:



1. Cell wall-------( )
2. Chromosomes-- --( )
3. Nucleolus-------( )
4. Nucleus-------( )
5. Chloroplasts----( )
6. Cytoplasm-------( )

4. The connecting up of words in 2 columns such as a column of organs and a column of functions.

Example:

a. Locomotion	1. Wing ( )
b. Feeding	2. Heart ( )
c. Digestion	3. Mandible ( )
d. Circulation	4. Tracheae ( )
e. Sensation	5. Antenna ( )
f. Respiration	6. Ovipositor ( )
g. Reproduction	7. Eye ( )
h. Excretion	8. Palp ( )

5. Other types of questions used to make up the test are:

True and false; arrangement of a list of words in the right order and questions demanding answers of one or a few words.

C. RUCH-COSSMAN BIOLOGY TEST

The "Ruch-Cossman Biology Test" is designed to measure the accomplishment of high school pupils after a year's work in biology. It may, however, be used at the end of a semester's study.

The questions in this test were compiled from a list of over 2000 examinations questions given by biology teachers from various parts of the country. The questions selected were those rated best among the most constantly recurring items.

This test contains 112 different items. Of these 28 per cent deal with plant life; 22 per cent with animal

life; 26 per cent with general material that might be botanical or zoological; 11 per cent with human biology and the remaining 13 per cent with heredity and evolution.

The general types of questions are similar to those of the Blaisdell Tests. Of the 112 items 58 are of the type where the pupil picks out one correct word or expression from several given. Another 35 items are of the "fill in missing words" type. Of the remaining 19 items, 15 deal with labeling of diagrams and 4 with figuring the number of offspring in Mendelian inheritance.

These questions--selected as they were from examinations given all over the country--ought to be indicative of the content of biology courses in general. They would thus serve as an excellent basis of comparison. A comparison of the content of biology courses given in Massachusetts shows little variation with the study made by Ruch and Cossmann.

VII. COLLEGE AND NORMAL SCHOOL ENTRANCE EXAMINATIONS AND THEIR EFFECT ON HIGH SCHOOL BIOLOGY

A. NATURE OF COLLEGE ENTRANCE EXAMS

College entrance examinations have long had a decided influence in shaping high school courses. The question now arises as to how much effect they have on high school biology. Do the high schools give such material as is dictated by the subjects covered in college and normal school examinations.

An analysis of a college board examination typical of most college examinations showed 24 per cent of the questions devoted to animal life alone,[1] 20 per cent to plant life, 20 per cent to heredity and evolution and 36 per cent of the examinations were questions involving a comparison or contrast between plants and animals.

Two facts were outstanding concerning this examination. One of these was the relatively large proportion of the examination devoted to heredity and evolution. The other was something that was conspicuous because of its absence, namely--questions on insects.

The study of some normal school biology examinations given since 1925 revealed 50 per cent of the questions to be in botany, 40 per cent in zoölogy and 10 per cent were questions in general biology.

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[1]Some of these questions might have been considered under another heading, human biology.

It was interesting to note that over one-half of all the animal biology concerned insects. The life history and economic phases were given most emphasis. The botany, outside of a couple of chapters on bacteria, emphasized structure function and adaptation of plants. Reproduction claimed over one-fourth of the plant questions. There was only one question on heredity.

The two outstanding differences in the college and normal examinations were the emphasis that each gave the study of insects and evolution and heredity. The college examinations contained almost nothing on insects and a large section on heredity and evolution. The normal school examinations reversed this emphasis. Both avoided human anatomy and physiology.

B. EFFECT ON HIGH SCHOOL BIOLOGY

From these facts it would seem that if either of the higher institutions exercised any control over high school biology that of the normal school was the more powerful. A much greater similarity existed between the high school courses and the normal examinations than with the college tests.

Very few colleges require biology for entrance. Most normal schools make biology a specific requirement. This might account for the apparently greater influence of the normal school in this case.

Most evidence, however, points to the fact that there is probably much less college influence over high school

biology than there is over many courses. This may account for the small degree of standardization in the subject. Biology has a freer course to run than most of its neighbors in the field of natural sciences.

VIII. OBJECTIVES OF BIOLOGY AND THE WAY MASSACHUSETTS' SCHOOLS ARE MEETING THEM

A. Views of Authorities on Objectives of Biology

Biology, like the rest of the sciences, should contribute directly to the cardinal principles of secondary education: health, worthy home membership, vocation, citizenship, the worthy use of leisure and ethical character. Leaders in the field of biology would, however, attribute some more specific aims to this subject.

TWISS George R. Twiss[1] after listing several principles to be observed in a biology course notes the following aims of the course:

1. Give pupils information of such biological facts and principles as are most directly and obviously related to human welfare and right living.
2. Give them training in methods of gaining for themselves information in this field of knowledge.
3. Give them opportunity to get an elementary grasp on a few of the great biological principles and methods of organizing biological knowledge.
4. Arouse in them abiding interest in plants and animals for the sake of the pleasure and intellectual profit and culture that such interest offers for employment of leisure out of doors.

WALTER H. E. Walter of Brown University in an address[2] before teachers of Rhode Island gave as the objectives of biology:

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[1] "Principles of Science Teaching" by George R. Twiss, Chapter 12

[2] "Teaching Biology in Secondary Schools" School and Society, January 25, 1930

1. To gain control of nature

   This aim he explained concerned the practical aspects of the subject, dealing with crops, domestic animals, health and sanitation.

2. To learn a body of organized facts about living things.

   This aim he says, deals with the cultural or aesthetic phases enabling wiser use of leisure time.

3. To practice the scientific method of thinking.

   This aim, Walter explained, would be to do away with superstition, to stimulate the forming of conclusions based on common sense rather than on hearsay evidence.

KINSEY

Alfred C. Kinsey[3] of Indiana University after decrying the morphology type of course and criticising the introduction of civic and human biology says that we should be concerned with t he content of the course which will best serve the average future citizen that,

1. it will awaken his interest in the living world in which he lives, and

2. equip him with the scientific method for interpreting that world.

N.E.A. COMMITTEE

One of the most complete set of aims for biology was formulated by the committee for the reorganization of science in secondary schools, a committee of the commission on reorganization of secondary education appointed by the National Education Association.[4] This committee gives

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[3]"The Content of the Biology Course" School Science and Mathematics, April 1930

[4]"Reorganization of Science in Secondary Schools" Bulletin 1920, No. 26, Government printing office, Washington, D.C.

the following aims:

1. The World War has emphasized health as a basic end of education. Since much of biology deals directly with problems of health, the course in biology must accept efficient health instruction as one of its chief and specific ends.

2. The biological sciences should develop the pupil's purposeful interest in the life of the environment by giving a first-hand acquaintance with plant and animal neighbors.

3. They should emphasize some of the most important applications of biological science to human activities and to general and individual human welfare, and e specially should familiarize the pupil with the structure and functions of his own body to the end that he may know why he must live healthfully in order to live happily and usefully.

4. They should train the pupil to observe life phenomena accurately and to form logical conclusions through the solution of problems and through projects essential to the productive work of agriculture, gardening, etc.

5. They should enrich the life of the pupil through the aesthetic appeal of plants and animals studied, to the end that he may appreciate and enjoy nature.

6. They should demonstrate to the pupil the value of intensive study of biological science as a means through which scientific progress is attained. In view of what science has meant to our present day civilazition and in view of the measure in which the methods and results of scientific investigations are to-day reflected in intelligent thought and intelligent action, the need of the life sciences in the education of modern citizens can not be ignored.

There are probably no objectives attributed to biology by modern educators that are not, at least, suggested by the list of 6 aims formulated by the science committee. It might seem, however, that some of the aims are duplicated. The following list of aims

suggested by the contributing of the foregoing authorities are somewhat more concise but still inclusive of all the main objectives.

1. To emphasize the most important applications of biological science to human health and welfare.

2. To develop such a purposeful interest in the life of the environment that the pupil may appreciate and enjoy nature.

3. To train the pupil to observe life phenomena accurately and to form logical conclusions.

4. To demonstrate the value of the study of biology as a means through which scientific progress is attained.

B. How They Would Accomplish These Objectives

1. THROUGH PROPER SEQUENCE

The committee of the National Education Association recommends that where the junior-senior high school system is in operation, biology be given in the last year of the junior high school, the 9th grade. For the four-year high school they recommend the 10th grade. They suggest advanced elective biological courses in the following years.

In regard to sequence of the subject matter in the course itself they emphasize only the fact that coherence and unity are important. Although they would encourage interrelations between sciences and the project method they believe that the study of isolated phenomena may result in a sacrifice of the ideals that sciences try to inculcate.

2. THROUGH PROPER CONTENT

In regard to content of the course there is one thing upon which all the authorities agree and emphasize, that is, that biology should be a study of living things. Kinsey says that we should have actual living animals rather than dissect and study "smelly structures."

Most of the authorities deplore the morphology type of course.[5] Structure is not the important thing for beginning students in biology. The study of the habits of living organisms is the important thing and structure should come in only when it becomes necessary in showing how an animal is adapted to the environment.

The N.E.A. committee believes that the central ideas in content should be:

1. The way in which each organism maintains its own life and the life of the species.
2. The interrelations between different organisms and groups of organisms.
3. The constant dependence and interrelations of living things with the physical world about them.
4. The power of man to control the habits and relationships of plants and animals to serve his own ends.[6]

The material for starting the course might be any

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[5]Alfred C. Kinsey, "The Content of the Biology Course", School Science and Mathematics, April 1930

[6]Government Printing Office, Washington, D. C. Bulletin 1920, No. 26

interesting topic as "The war between organisms which is being waged in a vacant lot" or "A balanced aquarium." The topic related would depend a great deal upon the interests of the pupils.

This study of the struggle for existence in plants and animals would lead to material concerning the functions of these organisms and the structure that enabled them to carry on this fight. The root, stem, leaf and flower could then be studied with more interest. The parts and the value of these parts of the insect would have more meaning to the pupil.

This might well be followed by material connecting these plants and animals with human welfare. Insects might be considered as enemies to plants and man. Birds could be studied as enemies of the insects and as friends to man. Mammals and their relation to man should be given much more consideration.

The science committee suggests that the course offer a good opportunity in giving much-needed help regarding the biology of sex. It believes that much good might result in this natural and nonsentimental approach to the subject. The caution is given, however, that because of much popular opposition to sex education it would be wise to advance slowly.

One other suggestion of the science committee in regard to content is that the pupils be acquainted with

the contributions of great biologists. Among others the work of Darwin, Pasteur, Harvey and Mendel could well be emphasized. This would help attain the committee's sixth objective.

A point that Kinsey urges is no particular part of biology be over emphasized. Using Kinsey's own words, "Finally, I would urge that our introductory course present a balanced picture of reality instead of more intensive study of a single aspect of science."

In one respect Kinsey differs somewhat from most of the authorities. He believes that civic biology, hygiene, public sanitation and economic biology have no place in a regular introductory course. This type of content he declares is a reaction to the old morphology type. The study of human hygiene he would place in the pre-secondary school years.

George R. Twiss believes that the study of the theory of evolution has one of the greatest values possible for youth; values that can be utilized in other fields of endeavor. Life he declares is a continuous race-struggle for existence. Qualities that are handed on have survival value. Through analogy to biological evolution the development of our customs, our laws, even our characters can be shown. I wonder if this would not be one of biology's contributions to the realization of that cardinal principle of secondary education dealing with character building.

3. THROUGH PROPER METHODS

How is this content to be presented? Twiss emphasizes the fact that form and structure should be presented as related to function. Function must, however, be the starting point. These in turn are related to adjustment, a factor which has physiology and ecology as its dynamic phase and morphology as its static phase.

Twiss then follows with these words that perhaps best convey his ideas on how biology should be presented. "Out of this relation comes another important principle in biological pedagogy; study structure and function together, as related to adjustment in one type and compare with analogous adjustments and the structure and functions related thereto in other types."[7]

A course in biology should be given as a unit and not as botany or zoology. It should be a "synthesized program" dealing with phenomena common to both worlds. This is Kinsey's idea of presenting biology but Kinsey is not alone in these views.

The N.E.A. science committee emphasizes field work. A good laboratory is only a fair substitute for out-of-doors. Living things to be appreciated must be studied alive and in their habitat.

In brief the chief features to be considered in presenting biology are: emphasize function and adaptation

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[7] George R. Twiss, "Principles of Science Teaching" Chapter XII.

rather than structure, to not draw sharp lines between botany and zoology and study living things in their natural habitat.

C. Changes in Point of View in Biology Teaching

The old secondary school iology course was really a diluted type of college course. Morphology and classification formed the chief content. The examination of preserved specimens of plants and animals constituted the laboratory work.

This is now giving way to the physiological and ecological phases of the subject. Adaptation is being given prominence. Above all actual living things are being studied.

Biology is now being presented not as something remote. It is being taught in its relation to human welfare. It is being connected with experience in the every day lives of the pupils.

D. How Massachusetts' Schools are Accepting These New Views

1. AS TO SEQUENCE

The schools of the state have accepted to a fair degree the suggestions as to the year in which biology should be given. Over 70 per cent present the subject in the tenth grade. This year, however, is suggested for 4 year high schools only, the ninth grade being suggested for junior high school systems. There are many 3 year high schools that offer the course in the tenth grade. Very few high schools offer special, elective, advanced courses in biology.

2. AS TO CONTENT

One of the outstanding suggestions as to content was that the course should contain the study of living things. This the schools seem to be doing more and more. But as yet most school classes in biology see only life that can be brought within the walls of the school building.

Material on morphology is still given to a large extent. But without doubt, as shown in section V, the schools are giving much more of the physiological and ecological aspects of the science. Although schools are tending more and more in this direction there is still much chance for improvement in most of the schools of the state.

The introduction of the theory of evolution as suggested by Twiss has been brought about, in some degree, by about 80 per cent of the larger schools of the state. only about 40 per cent, however, teach the subject in any detail. The others "just mention it" give it "incidently" or by "implication."[8]

Schools could with profit spend much more time on the vertebrates especially the mammals. In many schools of the state vertebrates form only about one-fifth of the work on animal life and much less work than this is given to mammals. Most authorities advocate that at least one-half of the study of animal life be devoted to the vertebrates.

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[8]Data from questionnaire sent to schools in the state having over 1 00 pupils.

3. AS TO METHODS

The chief point advanced as to good methods in biology is that which places function, physiological need and adaptation first. This point most of the schools seem to be meeting. The purely morphological course is a rarity in this state.

The "synthesized program" advocated by Kinsey, Hunter, Peabody and others, has been less generally accepted. Most schools in Massachusetts still give their sections in botany, zoology and human biology. This does not mean that they do not show the relationship between plants and animals; merely that they devote different parts of the year to emphasize each of the different divisions of biology.

The chief suggestion of the N.E.A. science committee as to methods was that the pupils be given more field work, that they study the plants and animals in their natural habitat. Of all the methods suggested the schools of the state fail most completely on this one.

In answer to the question "How much field work do you give?", 75 per cent of the larger schools said, "None". The remaining 25 per cent said that it varied. Most of these added that there was very little done.[9]

The chief cause for this state of affairs--it should be said in fairness to the teachers--is that there

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[9]Data from questionnaire. op. cit.

is little opportunity for this kind of work in the larger places. Schools are too far from the natural habitat of wild plants and animals. This is one of the problems that must yet be solved before we can have the ideal course in biology.

IX. SUMMARY

Interest in biological subjects has shown a great increase in the schools of Massachusetts. At present over 80 per cent of the schools are presenting biological subjects of some nature.

The regular introductory course generally called simply--biology--is the most popular of these courses. Approximately 70 per cent of the schools give this course. Of the remaining courses, physiology and hygiene and separate courses in botany and zoölogy are in the lead.

An average of 18 per cent of the pupils of the state are taking biology. A survey of the larger schools showed that girls were somewhat in the majority. In several schools, however, boys equalled or surpassed the girls in number.

The tenth grade is chosen specifically as the year in which biology should be given in 57 per cent of the schools. There are 21 per cent that give an option of different years.

Although the time given to biology varies in different schools, most schools give the subject 5 periods per week. For laboratory work 2 periods per week is most prevalent. As to field work practically no time is given.

There is very little uniformity in laboratory equipment possessed by the different schools. Most of the larger schools, besides a fair amount of individual equip-

ment have work tables, one or two compound microscopes, a human skeleton, charts, and an aquarium. As a whole the biological laboratories fall behind those of chemistry and physics.

The subject matter given in the schools is represented in 6 textbooks which are found in the greater number of schools in Massachusetts. Two of these books represent over 50 per cent of all the schools.

These books fall into 2 classes. The texts in the first of these classes take up the material in separate sections of botany, zoölogy and human biology. The other books present the material as a synthesized course, obliterating the lines between plant life, animal life and human biology.

These books give an approximately equal amount of botany, zoölogy and human biology. Some add sections on economic biology. Heredity and evolution are as a whole given little treatment by most of the texts. A few of the books have good sections on historical biology.

Many schools are tending towards more objective examinations. The Blaisdell instructional tests and the Ruch-Cossmann final test are the most common standard examinations given. These follow the standard texts very closely.

That college entrance examinations have a very decided influence on high school biology can not be proved. Of any little effect that entrance examinations might have

on the subject most can be attributed to the normal school examinations. The

The objectives in biology upon which most authorities agree are:

1. To emphasize the most important applications of biological science to human health and welfare.
2. To develop such a purposeful interest in the life of the environment that the pupil may appreciate and enjoy nature.
3. To train the pupil to observe life phenomena accurately and to form logical conclusions.
4. To demonstrate the value of the study of biology as a means through which scientific progress is attained.

The outstanding contributions as to how these objectives should be met are: teach actual living organisms in their natural habitat rather than preserved specimens; emphasize function and adaptation rather than structure; and demonstrate wherever possible the application of plants and animals to human health, disease, sanitation and general human welfare.

Most of these objectives Massachusetts schools are meeting. A few should make a little more progress in breaking away from the morphology type of course. Where the schools fall down most completely in this plan is in the studying of actual living organisms in their natural setting. This most schools have little opportunity to do.

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